Progress in Engineering Application and Technology Vol. 2 No. 2 (2021) 938–946

PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Electric Motor Selection for Electric Go-Kart Development

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DOI: https://doi.org/10.30880/peat.2021.02.02.085
Received 13 January 2021; Accepted 01 March 2021; Available online 01 December 2021

Abstract: The go-kart can be use as family fun kart but depends on several factors including the safety, costing and pollution. The construction of this electric go-kart is to reduce the release of toxic and harmful gases released from the combustion of engines using gasoline sources and the noise that came from the go-kart. The toxic gases released can cause adverse effects on the environment and the human respiratory system. Furthermore, the noise that came from the vehicle may harm the hearing people that drive it and people that around the area especially kids. By considering the actual go-kart engine power, by comparing the electric motor with the go-kart engine. The aim of this project is to select the suitable electric motor to replace the go-kart engine. All the electric motor selected by comparing their Power of motor (W), Battery Power Supply (V), and Horse Power (HP). The result then will be compared with other type motor which are Brushless DC Hub Motor, Stepper Motor, Hysteresis Motor, Reluctance Motor, and Universal Motor. At the end of study, the Brushless DC Hub Motor has been stated as the mechanism to replace the go-kart engine. This study uses no-load test, which is run the electric motor without any load and chassis. This test is to measure the mechanical losses of the chosen electric motor. From the data had been measured, we can see the losses by plotting the graph.

Keywords: Crash Analysis, Explicit Dynamic

1. Introduction

Go-kart is a simple four-wheeled, small engine, single Seated racing car used mainly in United States. They were initially created in the 1950s, Post-war period by airmen as a way to pass spare time. Art Ingles is generally accepted to be the father of karting. He built the first kart in Southern California in 1956. From then, it is being popular all over America and also in Europe. A go-kart, by definition, has no suspension and no differential. They are usually raced on scaled down tracks, but are sometimes driven as entertainment or as a hobby by non-professionals. Karting is commonly perceived as the stepping stone to the higher and more expensive ranks of motor sports. Kart racing is generally accepted as the most economic form of motor sport available. An electric go-kart is a type of go-kart powered by

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electric motors and batteries, as opposed to traditional petrol engine. Electric go-karts are mostly intended for recreational usage, though high-performance models for a more serious kart racing are also offered [1].

The aim of this project is to select the best electric motor for the go-kart development. An electric motor work by converting the electric energy to mechanical energy to create motion. The most important type of motor and drive, including conventional, brushless DC, induction motors and synchronous motor [2]. The idea of personal electric vehicles is becoming more popular in recent years. Many people including adults and children like to spend their free time with indoor go-karting [3]. Electric vehicles are energy-effective, fuel-saving and emission-less transportation [4]. The requirements of electric vehicles on electric motor drives can be summarized as:

i. High instant power and a high-power density.
ii. High torque at low speed for starting and climbing.
iii. Wide speed range with constant-power region
iv. Fast torque response.
v. High efficiency over the wide speed range.
vi. High efficiency for regenerative braking.
vii. Compact size, low weight, and lower moment of inertia.
viii. High reliability and robustness for various vehicle operating conditions.
ix. Reasonable cost.
x. Fault tolerance

The aspects that be consider in selecting motor are application, operational, mechanical, and environmental issues [5]. In motor selection, the ideal motor depends on the application which is constant speed, variable speed, or position control [6]. Karting can be performed by young and adult at free-time activity. It can be drive without license and it is can be considered as the first step in any serious racer's career [7].

1.1 Problem Statement

In this study, the problem issue that been proposed is the pollution that occur from go-cart engine. The go-kart engine use fossil fuel as their burning to move the go-kart. From that, the harmful gas go-karts exhaust cause of many respiratory and other diseases. The activities by rapidly can cause the major cause of air pollution. Thus, it can cause asthma, bronchitis, and many other diseases. Other than that, the go-kart engine can also cause the noise pollution. The sound that sounded from the go-kart engine can causing hearing loss if the sound is more than 85 decibels (dB).

1.2 Objective of Study

The objectives of this study are:

- To study the maximum load that can be carried by the electric motor.
- To determine and suggest suitable electric motor to replace engine used by go-cart.
- To measure the mechanical losses of the motor.
- To investigate the cause of the mechanical losses.

1.3 Scope of Study

This study is conducted based on the identified scope as follow:

- The study focuses only the power of electric motor and the effect on the go-cart toward optimum performance.
- These project point on the electric motor selection and the mechanical losses of the chosen motor.
- Focus on the built of electric motor go-kart.

2. Methodology

This section shows the activities carried out during the duration of the project. From this chapter all the implementation steps used, the flow chart and Gantt charts and the description of the components will be described in more detail. In order to execute a project, it requires a specific method or procedure to implement the process of producing a project. This process involves the beginning of the project title selection. In creating a project, there are several steps that need to be taken before the project is completed. These steps need to be done with great care in order to produce a quality and quality project. In producing this project, several steps have been taken. The following description describes the methodological steps. Arranging is one of the most critical stages for each task to be finished effectively. A decent and methodical arrangement guarantees smooth execution of develop process brings about efficient and positive result.

The goals and requirements in the electric motor selector are based on the inputs comprising the specifications, production data and controlling values, as well as the existing knowledge and core competences. The latter along with the used manufacturing technology can be decisive factors choosing the type of motor that has to be developed. The specifications include requirements such as working points, power and efficiency, weight and costs. However, the testing of motor is no load test. Costs are calculated from the supplier and consider the specification of the electric motor. Due to the inherently lower efficiency of the motors employing low-cost technologies, it has to be designed either with a larger outer diameter or with a combination of more length and higher input power, in order to fulfil the same working points. Therefore, decisions on costs require both information on the used manufacturing technologies as well as the used materials, as the electric motor selection can be influenced by a less balanced manufacturing line due to the lower investments needed to acquire new equipment. Particularly the chosen motor is a brushless DC hub motor as it is the "standard" motor choice in the automotive industry and it is higher efficiency, compactness and robustness.

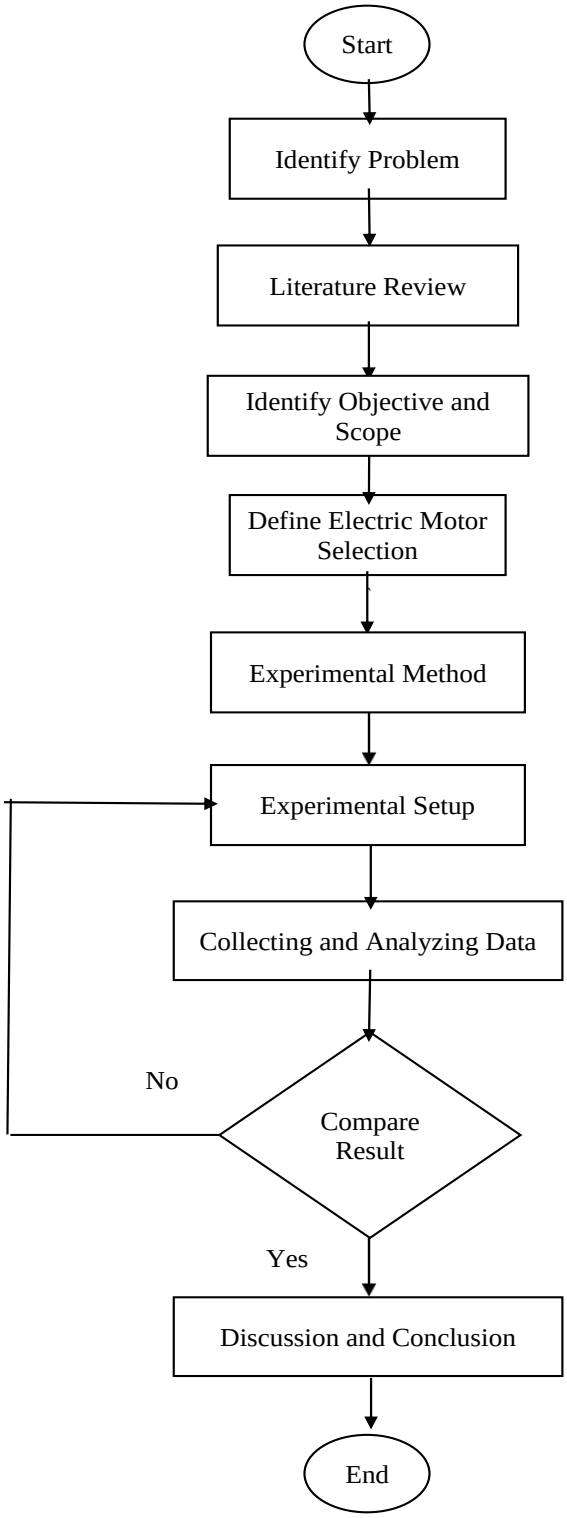

Figure 1: Methodology Flowchart

2.1 Prototype Development

Design products that meet the specific requirements and ensure that they are manufactured to address existing concerns especially on daily and usually used by the customer and consumer of go-kart. The design of the go-kart must comply with several aspects. Design considerations must be

carefully planned so that the design can be done and all components can function as intended. An aspect to consider in designing an electric go-kart is:

I. Electric Motor Power: It must have a certain power to make sure it can move the go-kart chassis and the driver.
II. Electric Motor Input: If the power input is too high, it needs more power supply to run the motor. Other than that, the cost needs to spend at the power supply also high.

2.2 Electric Motor Power

Power is work performed over a specific amount of time. In a motor, power is delivered to the load by converting electrical energy per the following laws of science. The power usage calculated in (Watts) for anything that is plugged into it. Accurate power measurements can help to reduce energy consumption, as measurement is always the first step toward better performance and can also help extend the life of a motor. Small misalignment or other issues are often invisible to the naked eye, and the slightest wobble in a shaft can negatively affect productivity and quality, and even shorten the life of the motor. Electric motors are electromechanical machines that convert electric energy into mechanical energy. Despite differences in size and type, all electric motors work in much the same way: an electric current flowing through a wire coil in a magnetic field creates a force that rotates the coil, thus creating torque. In electrical systems, voltage is the force required to move electrons. Current is the rate of the flow of charge per second through a material to which a specific voltage is applied. By taking the voltage and multiplying it by the associated current, the power can be determined. $P = VI$ where power (P) is in watts, voltage (V) is in volts, and current (I) is in amperes.

2.3 Electric Motor Input

Input power is the product of input voltage and input current, and is strictly a measure of the electrical power that the motor consumes. Output power, however, is a measure of how much mechanical power that the motor can deliver. Brushless DC hub motors designs are highly efficient and are optimal for battery-powered applications. For high efficiency in high-speed applications, Portescap also offers a brushless DC hub motor design that is slot less, which significantly reduces joule losses.

2.4 Product Testing

Testing this product is by testing the effectiveness of this product to see if it works well and according to the requirements. The test that be used are no load test. Based on the no load test we can get the voltage and current value. On the data, we can use it to measure the mechanical losses. From that we can measure the losses occur due to the air inside the rotating coil of the machine. The focus is to investigate whether the electric motor can carry the load from the chassis and also the weight of the driver electric go-kart or not without forget the optimum speed of the go-kart. Moreover, the electric motor must be able to maintain the performance on the life cycle, where the battery often used during the test.

2.5 Product Cost Estimation

Estimated cost is the cost involved in the production of a product. The cost of this product includes costs such as start-up costs, material costs, and equipment costs. The cost is the same as the money needed to buy a piece of components and tools. The cost of this product varies according to the current market such as electric motor prices and the regulator needed. The most important factor in the production of this product is the cost of materials as there are many aspects to consider in the production of this product.

3. Results and Discussion

Based on the objectives of this study, the result will be to produce a prototype design of electric go-kart which is the power of the motor is same as go-kart engine by using electric motor. Thus, consider

the optimum use of battery consumption so the go-kart will run at consistence power that same as the vehicle engine to carry load of the go-kart chassis and the driver of the go-kart.

The speed of the go-kart can be adjusted by using the special controller that been connected to the electric motor and power supply. Besides that, the electric motor meets the requirements and characteristics set in order to complete and simplify the process of movement on the go-kart with the optimum speed. The special regulator also is the important part to make sure the speed of the go-kart can be adjusted as usual go-kart.

All the motor had their power and their power supply needed to achieve the power. Table 1 shows the electric motor that can be used to build up electric go-kart as their mechanism to move the vehicle and replace the go-kart engine.

From the table, the Electric power is 1.5 kW which is the power output of the electric motor. The power output is taken from the actual electric go-kart engine. Unfortunately, the horsepower of the go-kart engine is 2.5 HP but all the electric motor get only 2.0 HP which is 0.5 HP less then targeted requirement. The stepper motor and hysteresis motor need 220 V as the source of power supply. Thus, reluctance motor and universal motor 230 V as the power supply. The power supply for the brushless DC motor is the best amount the follow the requirement, that had two model which are 36 V and 48 V.

Table 1: Specifications for selected electric motor

Electric Motor Type	Brushless DC Hub Motor	Stepper Motor	Hysteresis Motor	Reluctance Motor	Universal Motor
Electric Power (kW)	1.5	1.5	1.5	1.5	1.5
Battery Power Supply (V)	36/48	220	220	230	230
Horse Power (HP)	2	2	2	2	2

The DC test is performed to compute the flux resistance and a DC voltage is applied to the flux of an DC motor. The resulting current flowing through the flux is a DC current. Thus, no voltage is induced in the rotor circuit, and the motor reactance is zero. The flux is the only circuit parameter limiting current flow. Four batteries 12-V DC needed to give the power source became 48-V is applied to the DC motor. A group of light bulbs are installed in the circuit as a resistive load in order to adjust DC current to the rated value. The current in the flux and voltage across the motor are measured.

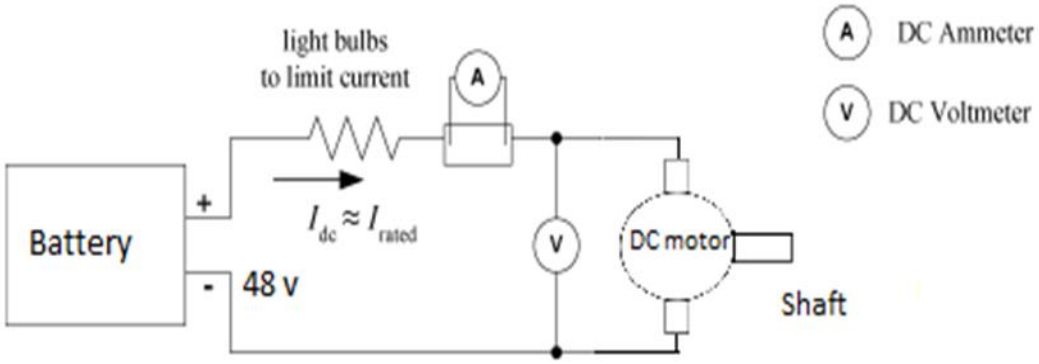

Figure 2: Experimental Setup

Specifications:
Electric motor – 6000 W
Battery – 48 V (4 cells 12V)
No-load test for the induction motor
The rating for the induction motor that was used in this study as shown in the Table 2.

Table 2: Induction Motor Rating

Power	6000	W
Voltage	3 x 27	V
Frequency	100	Hz
Speed	2850	rpm
Current	168	A
Weight	19.2	kg

Copper losses at stator winding, core losses and mechanical losses were measured using no-load test. The test was done by operating the motor at rated voltage and frequency without a load connected to the rotor shaft.

Table 3: No-load Test Result

Voltage (V)	Current (A)	Power (W)
12.67	27	214
23.3	46.5	298
26.05	52.5	338
30.2	62	396

From the data that been taken, by plotting Power (W) vs Voltage Squared (V^2) graph shown in Figure 3. The graph shown the trend is increase due the Voltage Squared. The equation of the graph is $y = 58.6x + 165$ which means the gradient of the graph is 58.6 and the intersection of the graph is (0,165). The intersection shows that the value of Voltage Squared is 165 V^2 and the Power is 0 W. It is happening because of the mechanical losses from the Electric motor from the experiment. A DC motor will have their mechanical losses because of the winding loss. During the current flow through the winding it will have resistance in the winding and these losses occur. Thus, the brush contacts also attributes to resistance between the surface of brush and commutator. Then, practically it can be seen it

occur because mechanical friction from the moving part which are bearing (type of bearing and the lubrication) that at some condition it will produce sound of friction. The aim of measuring the value of mechanical losses is because to predict the actual power of the motor.

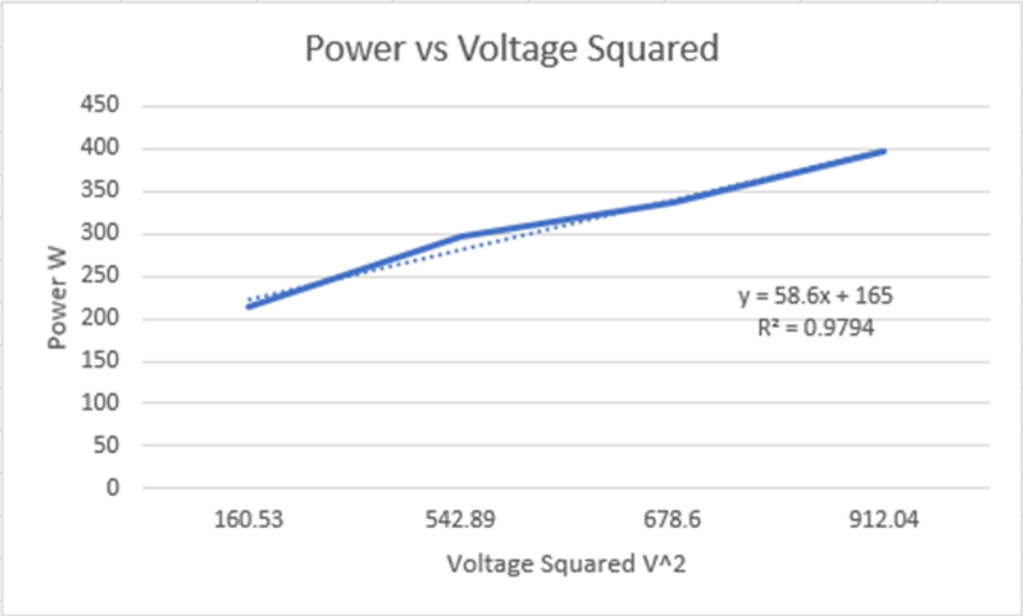

Figure 3: No-load Test Result

4. Conclusion

As the conclusion, the result will be used to produce a right way design of electric go-kart which is has a right and suitable electric motor that can be use as the moving mechanism to replace the engine. Even the power of this electric motor is not same as the actual go-kart engine, but the target is archive to reduce the pollution. So, we can say that go-kart is still relevant activities that can be proceed when been use an electric go-kart. Every result and data from the test need to be consider as the guideline to develop the electric go kart. Dc brushless hub motor had been chosen as the electric motor to replace the actual go-kart engine because of their characteristic and the power that archive as the engine go-kart. The pollution that usually occurred when used the go-kart engine and these solutions are used to overcame the problem. This no-load test was carried out to get the data because we as a team we cannot to gather and archive the plan. From the data we get the value of mechanical losses by plotting a graph power(W) vs voltage squared(V^2). From our research we able to investigate the mechanical losses which is from the winding losses, mechanical friction, and resistance between surface of brush and commutator. The actual plan is to assemble the go-kart with the chassis and the battery supply. But because of the pandemic Covid-19 we only able to make it by individually and manage to focus on the objective.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

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